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How To Estimate the Atomization of Oil-Base Aerial Sprays by the D-Max Method

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The drop size of aerial sprays is an important factor influencing deposit distribution, evaporation, and drift (Isler and Thornton 1955). Therefore, some measure of atomization is essential in aerial spraying research and for checking equipment on spray projects.

The degree of spray atomization is commonly expressed as mass median diameter (mmd). The mmd is the drop diameter dividing the spray volume in two equal parts -- 50 percent of the volume is in drop sizes below mmd and 50 percent is above mmd.

Conventional methods for determining mmd require sampling and measurement of many drops of all sizes (Maksymiuk 1963a). Therefore, they are slow and complicated, requiring special equipment and trained personnel. A rapid and simple method has been developed for estimating mmd from the largest drop in the continuous spectrum (D-max). Under this method, it is only necessary to determine the size of the five largest drops for each test flight.

The D-max method saves more than 90 percent in time without loss of accuracy or precision as compared to the method requiring measurement of drops of all sizes. It has been successfully tested over a wide range of spray atomization (82 to 450 microns mmd) using oil-base sprays. The sprays tested were No. 2 fuel oil and DDT oil formulations commonly used in forest insect control. The accuracy of this method outside this range of spray atomization and for other formulations has not been determined.

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The D-max method and its development have been described in detail elsewhere (Maksymiuk 1963b). This paper presents simplified procedures for its use in the field.

PROCEDURE

Suggested procedures for determining mmd by the D-max method are as follows:

I. Spray Equipment

1. Make sure that all spray nozzles are the same and oriented in the same direction.

2. Adjust the spray application rate so that it does not exceed 1 gallon per acre. Higher application rates might result in overlapping of drops on the assessment cards, making it difficult to determine their size. The application rate can be reduced by using fewer nozzles. In doing this, the spray pressure must not be changed because it affects the drop size. When it is not practical to reduce the application rate, fly the spray plane higher and crosswind so that small drops are blown away from the center of the flight line.

II. Drop Sampling

1. Collect undyed spray on dyed oil-sensitive cards (White 1959) or black-dyed spray[2] on undyed cards (Maksymiuk and Moore 1962).

2. Set out a line of about 40 cards on a runway or in an open area, preferably with the direction of the wind (see fig. 1). Use wire card holders (Maksymiuk 1959) to support them above any ground vegetation. Place cards as follows:

   a. At 10-foot intervals for slow-speed planes (about 80 to 100 mph) like the Stearman and Piper and

   b. At 20-foot intervals for medium-speed planes (about 150 to 180 mph) like the TBM, DC-3, B-18, and B-17.

III. Flight Procedures

1. Spray over the cards at a right angle to the sampling line (fig. 1).

[2] 2 lb. oil-soluble Sudan black dye (made by General Dyestuff Corp.) per 50 gallons of oil-base spray. (Use of company or brand names in this paper does not imply sole endorsement of the products mentioned.)

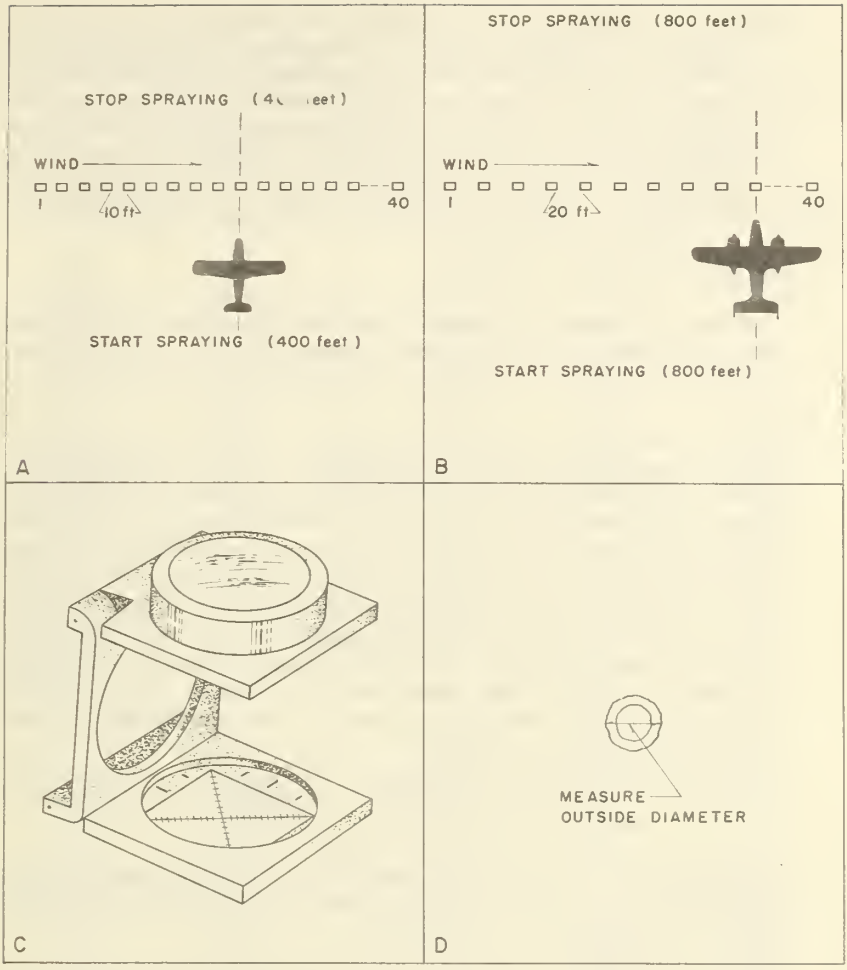

Figure 1.--A, Arrangement of sample cards for small planes; B, arrangement of sample cards for large planes; C, linen tester equipped with eyepiece reticle for measuring spot diameters; D, halo surrounding spots on dyed cards.

a. Slow-speed planes. Spray from a height of 50 feet or more; turn on the spray about 400 feet before the sampling line and turn it off about 400 feet beyond it.

b. Medium-speed planes. Spray from a height of 100 feet or more; turn on the spray about 800 feet before the sampling line and turn it off about 800 feet beyond it.

2. Meteorological conditions are not critical, provided windspeed is less than about 8 mph and there is no

rain. At higher windspeeds, the drops often produce oval or streaked spots of meaningless dimensions. When crosswind flights are made, the largest drops, from which D-max is selected, will fall under the airplane or will be slightly shifted downwind. The smaller drops will be carried on downwind and will not overlap or be superimposed on the larger drops. Therefore, a crosswind from 1 to 6 mph is desirable.

IV. Determining Drop D-max

1. Allow at least 10 minutes for the drops to spread and dry on the cards before measuring the spots; allow more time for very large drops.

2. After the spots cease to spread, select and measure the diameters of the 5 largest spots, including the halo if dyed cards are used (fig. 1). Measure them to the nearest 100 microns (0.1 mm). The spots can be measured with a microscope eyepiece reticle, graduated in 100 micron units. This reticle can be used either in a microscope or attached to the bottom of a linen tester or other magnifier with scotch tape. A linen tester gives a direct measurement because it magnifies both the spot and the scale at the same rate. Reticles and linen testers can be bought at any scientific supply house.[3]

   Tabulate the spot diameters in order of decreasing size as shown in the example under step 4 below.

3. Convert the spot diameters to spherical drop diameters. This is done by dividing the spot diameters by the proper spread factors.

   The spread factor shows how much drops spread on the cards. It varies with drop size and the components of the spray formulation. It is determined in advance for the drop sizes, spray, and sampling surface to be used. It is obtained by dividing the diameter of spherical drops of known size into the outside diameters of the spots they produce on the assessment card (Maksymiuk and Moore 1962). Determination of spread factor requires specialized skill and equipment. When rough estimates of mmd will suffice, Table 1 will be adequate for most oil-base spray formulations.

4. Select spherical drop D-max as the largest drop diameter with not more than 32 microns difference

[3] For example: Edmund Scientific Co., Barrington, N.J. Crossline reticle, scales 10 mm in 100 parts, stock No. 30075 ($7.50); Linen tester magnifier, 6X lens diameter 1 inch, stock No. 40030 ($1.75).

TABLE 1.--Estimated mmd for slow and medium speed planes using spread factors for a DDT oil spray[1] on dyed Kromekote paper cards

Spot diam., microns	Spread factor	Spherical drop diam., microns	mmd, microns	
			Slow speed	Medium speed
1000	5.74	174	79	70
1100	5.80	190	86	76
1200	5.85	205	93	82
1300	5.90	220	100	88
1400	5.94	236	107	94
1500	5.97	251	114	100
1600	6.00	267	121	107
1700	6.03	282	128	113
1800	6.05	298	135	119
1900	6.07	313	142	125
2000	6.09	328	149	131
2100	6.11	344	156	138
2200	6.12	359	163	144
2300	6.14	375	170	150
2400	6.15	390	177	156
2500	6.16	406	185	162
2600	6.18	421	191	168
2700	6.19	436	198	174
2800	6.20	452	205	181
2900	6.21	467	212	187
3000	6.21	483	220	193
3100	6.22	498	226	199
3200	6.23	514	234	206
3300	6.24	529	240	212
3400	6.24	545	248	218
3500	6.25	560	255	224
3600	6.26	575	261	230
3700	6.26	591	269	236
3800	6.27	606	275	242
3900	6.27	622	283	249
4000	6.28	637	290	255
4500	6.30	714	325	287
5000	6.31	792	360	317
5500	6.33	869	395	348
6000	6.34	946	430	378
6500	6.35	1023	465	409
7000	6.36	1100	500	440

[1] Spray formulation: 1 lb. DDT plus 1 quart of Sovacide (Mobisol 544-B) plus No. 2 fuel oil to make 1 gallon of spray.

between it and the next largest to it going from the smallest drop size up. In the following example drop D-max is 390 microns:

Spot diameter, microns	4000	3800	2400	2300	2300
Spread factor	6.28	6.27	6.15	6.14	6.14
Spherical drop diameter, microns	637	~~622~~ 606	390	375	375

Drops larger than D-max are found only occasionally. They are sometimes caused by leaks or by drooling of impinged spray from the equipment or the surfaces of the aircraft. If they are present, check your spray equipment.

V. Converting Drop D-max to Mmd

1. Obtain mmd as follows:

   a. Slow-speed planes. Divide spherical drop D-max by 2.2, or multiply it by 0.454.

   b. Medium-speed planes. Divide spherical drop D-max by 2.5, or multiply it by 0.400.

2. Since there is variation in mmd determinations from flight to flight (Moore et al. 1963), use the average of not less than 3 test flights.

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